INLINE TANDEM PUMP

Cross-Reference

This application is a continuation-in-part of U.S. Patent Application Serial No. 10/175,206 filed June 19, 2002. This application is incorporated herein by reference in its entirety.

Background Of The Invention

This invention relates to hydraulic pumps.

Summary Of The Invention

A dual tandem pump having an input shaft that is separate from the pump input shafts is disclosed herein. The details of this invention are set forth below in connection with the detailed description of the embodiments.

Brief Description Of The Drawings

Fig. 1 is an external side view of a tandem pump in accordance with one embodiment of this invention.

Fig. 2 is a cross-sectional view along the lines 2-2 in Fig. 1.

Fig. 3 is a cross-sectional side view along the lines 3-3 in Fig. 2.

Fig. 4 is a schematic of the hydraulic circuit of the embodiment of this invention shown in Fig. 1.

Fig. 5 is a cross-sectional side view of a second embodiment of this invention.

Fig. 6 is a schematic of the hydraulic circuit of the embodiment of this invention shown in Fig. 5.

Fig. 7 is a cross-sectional side view of a third embodiment of this invention.

Fig. 8 is a schematic of the hydraulic circuit of the embodiment of this invention shown in Fig. 7.

Fig. 9 is a side view of a fourth embodiment of this invention.

Fig. 10 is a cross-section side view of a fifth embodiment of this invention.

Fig. 11 is a cross-sectional view of the fifth embodiment of the pump apparatus shown along the lines 11-11 in Fig. 10.

Fig. 12 is a cross-sectional view of an end cap of the fifth embodiment of this invention shown along the lines 12-12 in Fig. 10.

Fig. 13 is a schematic showing the embodiment of Figs. 10-12.

Fig. 14 is a cross-sectional side view of a sixth embodiment of the present invention.

Fig. 15 is a top plan view of a further embodiment of this invention.

Fig. 16 is a top plan view of yet a further embodiment of this invention.

Detailed Description of the Drawings

One embodiment of this invention is shown in **FIGS. 1, 2, 3** and **4,** which depict a pump apparatus 10 having a unitary housing 12. In the embodiment described below, two generally identical pumps 11a and 11b are disclosed within unitary housing 12, and identical numerals with the letters a and b are used to reference identical parts. It will be understood by one of skill in the art that the two pumps 11a and 11b need not be identical and that substantial variations are possible to one or the other within the scope of this invention. Pumps 11a and 11b are shown as the rotating axial piston type, although other designs could be used with minor modifications within the scope of this invention. For convenience, only certain elements of pump 11a and its related structure are described in detail herein. It will be understood that the corresponding

structure of pump 11b is identical in the embodiments depicted and need not be similarly described.

Housing 12 forms two generally identical pump chambers or cavities 29a and 29b and a gear chamber or cavity 30 formed therebetween, thus providing an integral housing for the two pumps 11a and 11b. A pair of end caps 16a and 16b are mounted on opposite ends of housing 12 and act to seal pump chambers 29a and 29b, and may be secured thereto by screws 22 or another means. A cover 23 is secured to the bottom of housing 12 to close gear chamber 30.

With regard to pump 11a on the left hand side of **FIGS. 1, 2** and **3,** it can be seen that a pump cylinder block 31a comprising a plurality of axial pistons 38a is mounted on running plate 37a, which may be used for additional strength and durability. Cylinder block 3la could also run directly on a surface formed on end cap 16a. The porting in end caps 16a and 16b can be of the design shown in *e.g.,* U.S. Pat.. No. 6,332,393, the terms of which are incorporated by reference.

End cap 16a includes hydraulic porting 26a for the hydraulic fluid. System ports 41a and 42a are formed on the external surface thereof. In the view shown in **FIG. 1,** plugs 43 are used to seal system ports 41a, 41b, 42a and 42b for shipping; in use the system ports would be connected to hoses or the like. As shown in the schematic depicted in **FIG. 4,** ports 41a and 42a are connected to motor 40a while ports 41b and 42b are connected to motor 40b. Motors 40a and 40b could be wheel motors in a typical zero turn vehicle design; they could also be replaced with other hydraulic devices in other applications. A bypass 66a and 66b is provided for each pump 11a and 11b to permit, *e.g.,* movement of the vehicle when it is not under power.

Pump 11a is of the cradle mounted swash plate design; as shown in **FIG. 3,** swash plate 32a is mounted in pump chamber 29a on cradle bearings 46a mounted on the inner wall of housing 12. Pistons 38a run against swash bearing 33a mounted in swash plate 32a. Trunnion

arm 21a is engaged to a control block 45a that is engaged to swash plate 32a, so that rotation of trunnion arm 21a causes movement of swash plate 32a to the various stroked forward or reverse positions, or to the neutral position.

A shown in **FIG. 4**, an external reservoir 68 is used for storing hydraulic fluid. The hydraulic fluid is pulled from reservoir 68 through filter 65 into charge inlets 47a and 47b, and hence to charge pumps 18a and 18b, respectively. Charged fluid is driven into charge gallery 49a and then to the porting in end cap 16a, and a charge relief 75a is provided to keep pressures within the normal operating range. Since in this embodiment pump chambers 29a and 29b are sealed from one another, a plurality of case drains 69a and 69b are provided to remove oil from pump chambers 29a and 29b, respectively. The separate case drains 69a and 69b may be located in a variety of locations, such as end caps 16a and 16b. Check valves 67a and 67b are used to maintain the proper hydraulic flow within the end caps 16a and 16b. A pair of charge pressure relief valves 75a and 75b are connected to the porting for charge pumps 18a and 18b, respectively.

Input shaft 14 extends into housing 12; it can be driven by a prime mover (not shown) through a pulley, such as pulley 51 shown in **FIG. 2**, or some other means. Bevel gear 36 is mounted on input shaft 14 inside gear chamber 30 and is drivingly engaged to a second bevel gear 35 mounted on first pump shaft 27. Pump shaft 27 extends from gear chamber 30 into first pump chamber 29a and is engaged to and drivingly rotates pump cylinder block 31a. Bearing 44a provides support within housing 12. Pump shaft 27 is joined to and drives shaft 28 through coupler 34, which may be of a known design using a powdered metal part with splines to interlock the two shafts 27 and 28, or a cut steel part with a broached inner diameter to form the interlock, or a similar design. Pump shaft 28 also extends from gear chamber 30 into pump

chamber 29b where it engages and drivingly rotates pump cylinder block 31b in a similar manner. As shown in, *e.g.,* **FIG. 3,** input shaft 14 is generally perpendicular to pump shafts 27 and 28 and extends out the side of housing 12 as opposed to the ends thereof, which provides the user with flexibility in the application.

As shown in, *e.g.,* **FIG. 3,** input shaft 27 extends through end cap 16a into charge housing 20a to drive charge pump 18a, which can be a gerotor style such as is shown or some other style of charge pump, such as a vane pump, geroller, gear pump or any other known design. End cap 16a may be secured to housing 12 by means of screws 24 or the like. The location of input shaft 14 on the side of housing 12 permits the location of charge pumps 18a and 18b on opposite ends of housing 12. Specifically, charge pump 18a is located within charge pump housing 20a mounted on end cap 16a. A similar charge pump 18b may be mounted in a similar manner in charge pump housing 20b on the other end of apparatus 10. It is possible that only one of the charge pumps would be required, depending on the application for which the pump apparatus 10 is to be used. Similarly, the output of one charge pump mounted on one end cap could be attached by means of internal or external hoses or integral passages to provide charge pressure to the other pump associated with the other end cap.

It will also be understood that these embodiments could include additional gear reduction. For example, in **FIG. 3**, a gear reduction could be used between bevel gear 36 on input shaft 14 and bevel gear 35 on pump 27. Furthermore, it will be understood that bevel gears 35 and 36 could be replaced with another means for creating a right angle turn of the rotational force, such as helical gears, a worm gear driving a spur gear and the like.

FIG. 5 shows a second embodiment of this invention, where like numerals indicate identical structure with previous figures. A pump apparatus 50 has a housing 52 which creates a

gear chamber 56 and a first pump chamber 59a and a second pump chamber 59b. A case fluid passage 55a is formed in housing 52 to connect pump chamber 59a and gear chamber 56, and case fluid passage 55b similarly connects pump chamber 59b with gear chamber 56, both to permit hydraulic oil to flow between the pump chambers 59a and 59b and the gear chamber 56. Since both pump chambers 59a and 59b and gear chamber 56 are hydraulically connected in this embodiment, a single case drain 69 to permit oil to flow to reservoir 68 can be formed anywhere in housing 52; if it is in the gear chamber 56, as shown in **FIG. 6,** it will assist in preventing contamination of pumps 11a and 11b with debris from bevel gears 36, 35a and 35b and assist in reduction of heat, as the warmer fluid from pumps 11a and 11b will be carried to the center of the housing 52. It could, however, be formed elsewhere in the circuit depending on the application requirements. The use of a single case drain also reduces machining requirements and the number of fittings required.

In this second embodiment, input shaft 54 is driven by input pulley 51 and extends through housing 52, and through cover 53, which includes bearing 57 therein to support shaft 54. Output pulley 58 may be attached to the end of shaft 54 to drive an auxiliary device such as a mower deck or other device. Cover 53 is strengthened to support bearing 57 used to rotatably support shaft 54 and the torque loads from output pulley 58.

It will be noted that using through shaft 54 as the input shaft precludes the use of a coupler to drive the two pump input shafts 63a and 63b. An alternative means of driving these shafts is shown in **FIG. 5** where input shaft 54 has a first bevel gear 36 mounted thereon and drivingly engaged to a first driven bevel gear 35a mounted on and driving first pump shaft 63a and a second driven bevel gear 35b which is similarly mounted on and driving second pump shaft 63b. Such an alternative arrangement could also be used with the first embodiment in place

of coupler 34. A further benefit of this design is that pump shafts 63a and 63b can be sized appropriately for the pumps; only input shaft 54 needs to be sized appropriately to handle the torque of both pumps 11a and 11b as well as the torque requirements of the auxiliary device attached to output pulley 58.

A third embodiment of this invention is shown in **FIG. 7**, which is similar in many ways to the embodiment as shown in **FIG. 5**. Pump apparatus 70 includes a housing 72 with cover 73 secured thereto. Input shaft 74 extends through housing 72 and cover 73, where it is supported by bearing 77, to extend out of the gear chamber 56 to drive auxiliary pump 78 through coupler 76, which also may be of the internal spline structure or other known structure. Auxiliary pump 78 could alternatively be driven directly by input shaft 74, thus eliminating the need for the coupler 76. Optional hardened washers 25 may be mounted adjacent to gears 35a, 35b and 36 to provide support for such gears running against housing 72.

Auxiliary pump 78 is mounted in auxiliary pump housing 79 mounted on cover 73, and it can be used for driving external devices such as a deck lift or the like. The auxiliary out and auxiliary return are depicted schematically in **FIG 8**. As with the embodiment depicted in **FIG. 6**, this embodiment requires only a single case drain 69 to reservoir 68.

Yet another embodiment is depicted in **FIG. 9,** which is structurally substantially identical to the embodiment shown in **FIG. 1. FIG. 9** shows a pump apparatus 80, where the key differences with **FIG. 1** are that pump shafts 87 and 88 extend out of charge pump housings 82a and 82b, respectively, and input shaft 84 extends out of cover 83. A plurality of cooling fans 81a and 81b are mounted on pump shafts 87 and 88 respectively, while fan 81c may be mounted on input shaft 84. It is unlikely, though possible, that all three fans 81a-c would be needed for a single application.

One or more of fans 81a-c may be used depending on the application needs and if 81a and 81b are placed in the orientation shown in **FIG. 9**, so as to move air in the same direction, they may cooperate to generate a draft across housing 12 and reduce airflow turbulence. The use of such fans can in certain applications eliminate the need for an oil cooler. The most advantageous arrangement of the fans will depend on how apparatus 80 is located with respect to, *e.g.*, a vehicle engine or the like.

A fifth embodiment of this invention is shown in **FIGS. 10-13**, where pump apparatus 90 has a housing 92. This embodiment is similar in many ways to the previous embodiments and in particular the embodiment shown in **FIGS. 5** and **7** in terms of the arrangements of those items using identical numerals. The key difference in this embodiment is the use of a single charge pump 98 driven by input shaft 94 rather than a pair of charge pumps driven by pump shafts 93a and 93b. Charge pump 98 is mounted in a housing 99 secured to cover 95.

As will be understood, a described arrangement requires porting to be formed in both cover 95 and housing 92 to permit charge oil flow to pump cylinder blocks 31a and 31b. It would also be understood that such porting could be formed externally, *e.g.*, through hoses and the requisite fitting connecting charge pump 98 to end caps 96a and 96b. Input shaft 94 extends through cover 95 to drive charge pump 98. The input shaft may be further supported by bearing 77. An additional bearing 97 may also be provided.

As shown most clearly in **FIGS. 10** and **11,** housing 92 and cover 95 include a port 102 having a first leg 102a extending into the left side of housing 92 and into end cap 96a, and a second leg 102b extending opposite thereto and through the right side of housing 92 and into second end cap 96b. Charge inlet 104 is formed in cover 95 and connects charge pump 98 to reservoir 68, as shown in the schematic shown in **FIG. 13.** In the exemplary embodiment

illustrated in **FIGS. 10** and **11,** the bearing 77 also serves to divides the charge inlet 104 from the port 102. End caps 96a and 96b, which are secured to housing 92 by screws 22 or other fastening means may be generally identical and thus only one will be described.

End cap 96a has a pair of system ports 105, each of which has a corresponding poppet valve 106 connecting the kidneys 107 to the system ports 105. A screw type bypass 108 can be used with a bypass port 109 connecting the two sides of the hydraulic circuit to enable the user to place the unit into bypass. The key distinction from the prior embodiments is the use of single charge port 103, which may be drilled into end cap 96a, and which connects to port 102a to provide charge fluid from charge pump 98 to the hydraulic circuit of pump 11a.

As can be seen most clearly in **FIG. 12,** a mounting flange 110 can be formed on housing 92 to provide a means for securing the pump apparatus to a vehicle or the like.

One of the benefits of this invention is that the design affords flexibility to the user for different possible applications. For example, in **Figs. 1-3,** trunnion arms 21a and 21b are shown extending out of housing 12 on the same side as and thus parallel to input shaft 14. It will be understood that trunnion arms 21a and 21b could be mounted on any side of housing 12, possibly requiring a corresponding change in the orientation of swash plates 32a and 32b, respectively, and also possibly requiring a change in the orientation of end caps 16a and 16b, respectively. Trunnion arms 21a and 21b need not be on the same side of housing 12. By way of example, if trunnion arm 21a is rotated 180° from the orientation shown, housing 12 would need to be modified, but the orientation of end cap 16a would not need to be changed. If, however, trunnion arm 21a was rotated 90° from the orientation shown, end cap 16a would also need to be similarly rotated, along with the proper housing modifications. These changes are depicted in **FIGS. 15** and **16.**

Specifically, a view of such an embodiment is shown in **FIG. 15**, where pump apparatus 210 includes a slightly modified housing 212, where trunnion arms 21a and 21b are mounted on the same side of housing 212, but at a 90 degree angle from input shaft 14, so that trunnion arms 21a and 21b are perpendicular to both the two pump shafts 27 and 28 and input shaft 14. **FIG. 16** shows a slightly modified embodiment, pump apparatus 310, where trunnion arms 21a and 21b are mounted on opposite sides of housing 312. These changes are helpful to ensure that the unit can be installed in a wide variety of applications. For example, different vehicle applications use different linkages, and the ability to modify the pump housing in such manners affords the user maximum flexibility. It will also be understood that other types of swash plates 32a and 32b, such as a trunnion mounted swash plate, could also be used.

Another area where this invention provides increased flexibility is in the possible locations of the system ports. For example, in the embodiment depicted in **FIG. 12,** system ports 105 are located on the side of end cap 96 adjacent to mounting flange 110. In these embodiments, system ports 105 are parallel to the longitudinal axis of input shaft 94. This is in contrast to, *e.g.*, the embodiments shown in **FIGS. 1** and **9**, where system ports 41a, 41b, 42a and 42b are formed in end caps 16a and 16b, respectively, so as to be perpendicular to input shaft 14. These different embodiments again increase the flexibility afforded to the user of this design, so that it may be used in a wide variety of vehicles or other applications.

FIG. 14 shows an alternative embodiment similar to that shown in **FIG. 10,** except that charge pump 112 is mounted on the inside of cover 111, and thus inside the fluid sump formed inside housing 92. Cover 113 is formed to mount not only charge pump 112 but also bearing 77 for input shaft 114. Porting similar to that shown in **FIG. 11** will be formed in cover 111 to connect to ports 102a and 102b.

It is to be understood that the above description of the invention should not be used to limit the invention, as other embodiments will be obvious to one skilled in the art. This invention should be read as limited by the scope of its claims only.